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India's INDC for Transport and 2 °C Stabilization Target

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Transport sector accounted for 13 % of India's energy-related CO_2 emissions. India's Intended Nationally Determined Contributions (INDC) specify an economy wide decarbonization target of 33 to 35 % between 2005 and 2030 and includes announcements for urban transport, intercity transportation infrastructures, sustainable logistics and inland waterways to achieve these reductions. The Paris agreement that followed the announcement of the INDC increased the global ambition to stabilize the greenhouse gases so that maximum temperature rise is limited to 2 °C with an enhanced ambition for 1.5 °C. The paper analyses how far INDC will reduce the emissions from transport and to what extent a 2 °C temperature stabilization goal will decarbonize the transport sector. The analysis is carried out using ANSWER MARKAL model for evaluating the energy system in combination with a transport demand module to model future scenarios for India till year 2050. Three scenarios are explored in this paper: i) a business-as-usual scenario ii) an INDC scenario iii) implementation of INDC in a strong climate regime aiming for the 2 °C target. The assessment shows that CO2 reductions from transport would happen through a wide portfolio of options. The highest mitigation is achieved through sustainable mobility strategies, followed by fuel economy standards. Electric vehicles offer significant mitigation benefits, however these are more significant post 2030.

1. Introduction

India is currently the fourth-largest emitter of greenhouse gases (GHG) globally. The transport sector is a growing sector contributing 13 % of India's energy-related CO_2 emissions (MOEF, 2010). Increase in economic growth and consequently per capita incomes in future are expected to drive the demand for transport. This trend is expected to result in increased share of energy demand and CO_2 emissions from the transport sector (Dhar and Shukla, 2015). Going by the current trends, the high dependence on fossil fuels, now and in future, will pose challenges for energy security, air pollution in cities and climate (Dhar et al., 2015).
India's INDC sets a target for reducing CO_2 emissions intensity by 33 to 35 % between 2005 and 2030. Transport is a key area identified to achieve this ambition (UNFCCC, 2015a). The Paris agreement that followed the announcement of the INDCs increased the global ambition to stabilize the greenhouse gases to limit temperature to 2 °C with an enhanced ambition for 1.5 °C (UNFCCC, 2015b). The role of transport sector in mitigation consistent with a 2 °C temperature is well documented (Sims et al., 2014), however the transportation and buildings sectors contribution is significantly higher than electricity and industry towards meeting the 1.5 °C ambition (Rogelj et al., 2015). In this context, it is important to understand how far INDC will reduce the emissions and to what extent a 2 °C goal will decarbonize the transport sector.

1.1 Key Trends

India's passenger transport demand increased at over 8 % (Dhar and Shukla, 2015). Between 1970 and 2010, the share of rail transport has decreased (from 41 % in 1970 to 11 % in 2010), with a concurrent increase in share of road based transport. There has been a rapid growth in air travel though the share was still around 1 % in 2010.
Increased motorization was prominent trend in the recent decade with the share of households with two-wheeler ownership increasing by two and a half times between 2001 and 2011. Despite the growth, vehicle ownership

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in India is comparatively low and a high growth is expected to continue in future. Freight transport demand in India has also witnessed high growth and as with passenger transport, the share of rail has dropped from 66 % in 1970 to 40 % in 2010 (Dhar and Shukla, 2015). Coastal shipping carries 6 % of India's freight demand and the growth in the sector was slower compared to road and rail. The transport of the largest consumer of oil. India imports over 80 % of its oil resulting in significant macro-economic impacts.

1.2 Climate change policies in India

Transport sector contributed around 13 % of energy-related CO_2 emissions of India in 2010 (MOEF, 2010) and are expected to increase by over five times between 2010 and 2050 in the business as usual (Dhar and Shukla, 2015). Transport is an important focus area of India's climate strategy. The Indian transport strategy is based on sustainability paradigm and aims to reduce dependency on imported energy sources reduce GHG emissions and also mitigate the environmental impacts. India's National Action Plan for Climate Change (NAPCC) includes initiatives to increase the share of public transport, improve vehicle efficiency and enhance penetration of biofuels (GoI, 2008). India has recently announced its Intended Nationally Determined Contributions (INDC), with the objective of reducing the carbon intensity by 33 – 35 % between 2005 and 2030. Sustainable and green transport is emphasized as a strategy to achieve this ambition (UNFCCC, 2015a). The INDC are strongly rooted in the on-going policies and programs of government (Table 1).

Table 1: Overview of transport policies and links to transport in India's INDC (Dhar et al., 2015).

Sector	Ongoing Policy/plan	INDC target/ambition
Urban Transport	National Urban Transport Policy	Mass transit to play an important role
Urban Development	National Mission on Sustainable Habitat Smart City Mission Mission for Rejuvenation and Urban Transformation (AMRUT)	Reference to Smart City Mission and AMRUT to develop energy efficient climate resilient cities
Biofuels	National Policy on Biofuels	An aspirational blending target of 20%.
Electric Vehicles	National Electric Mobility Mission Plan (NEMMP) Faster Adoption and Manufacturing of Hybrids and Electric Vehicles (FAME)	Reference to electric mobility as one of the key areas and highlights the NEMMP and FAME
High Speed Rail Project	High Speed Rail Project	
Fuel Economy	Fuel Economy Standards for cars Auto Fuel Policy for fuel quality and vehicle emission norms	Shifting to Bharat Stage V and Bharat Stage VI in near future
Freight	Dedicated freight corridors (DFC) Jal Marg Vikas Sagarmala Baharat Mala	Increase share of Railways from 36% to 45% Dedicated freight corridors and energy efficient freight transport Promotion of coastal shipping and inland transport Integrated waterways network

2. Methodology

2.1 Scenarios

The paper assesses three future transport scenarios for India (Figure 1) to allow a comparison with a baseline of the INDC commitments and also to determine the gap from the global goal of 2 °C stabilisation since INDC actions are believed to fall short of the reductions needed for a 2 °C scenario (UNEP, 2015). The scenarios span a time period till 2050. In the business-as-usual (BAU) scenario, future development follows a conventional pathway in terms of policy interventions. The INDC scenario lays a strong emphasis on sustainable development. The scenario encompasses strategies for both demand and supply The demand side strategies for passenger and freight transport include the strategies that avoid the need for travel and the interventions that enable the shift to low emission modes (Sims et al., 2014). The supply side strategies include clean vehicle technologies and fuels.

The third scenario assumes the INDC interventions in combination with a strong climate regime. The interventions include those of the INDC scenario along with a global carbon price trajectory in line with the 2 °C climate stabilization target.
The projections for socio economic drivers are derived using logistic regressions and expert judgement for asymptotic values (Dhar et al., 2015). GDP growth happens at a CAGR of 7.1 % resulting in a growth of over fifteen times in 2050 relative to 2010. Growth rates for population and urbanization follow the UN projections (UN, 2014) and assumptions for average household size, vehicle ownership and income growth are based on Dhar et al. (2015).

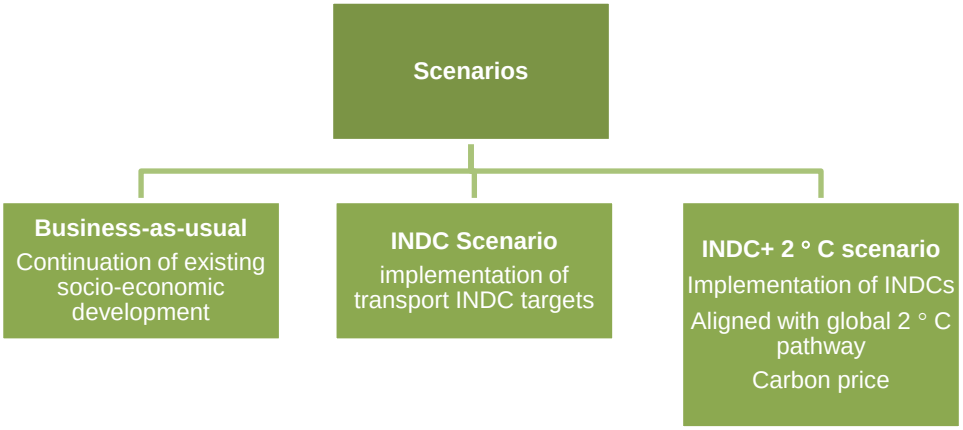

Figure 1: Scenario architecture

2.2 Model

Scenario analysis is carried out using a mathematical model ANSWER MARKAL. The model includes detailed descriptions of end-use technology, fuels and investment options, while keeping consistency with system constraints such as energy supply, demand, investment and emissions (Loulou er al., 2004). The ANSWER MARKAL model has been used for assessment of the Indian energy system (Shukla et al., 2015) and the transport sector of India (Dhar and Shukla, 2015). For the study, the model was further developed by segregating urban and intercity passenger transport, thereby allowing for a more detailed technology characterization.

3. Policy Analysis

In the BAU scenario the CO_2 emissions from transport sector would increase to 1,092 $MtCO_2$ by 2050, an increase of over five times from the 2010 levels. The cumulative emissions between 2010 and 2050 from transport sector alone would be around 26 x 10^9 tCO_2. Given that the total available CO_2 budget globally for remaining within 2 ^oC at 66 % probability is 1,000 x 10^9 tCO_2 (IPCC, 2013), these emissions unsustainable level. The INDC submitted by India has interventions on demand and supply side for transport and the paper analyses the contribution of these initiatives on CO_2 emissions. The INDC has in most cases made a reference to the key areas of intervention, however the ambitions and targets are not clearly laid out. Therefore, we have for our analysis tried to analyse if these strategies can be implemented to their full potential and with a time horizon going beyond 2030 since the full benefits for these actions may not be evident in the short term. In Sections 3.1 to 3.5, we analyse individual transport INDC strategies and their contribution to mitigation of CO_2 emissions and energy savings relative to the BAU Scenario. Section 3.6 compares the CO_2 emission reductions of the INDC scenario with the INDC + 2 ^oC scenario vis-a-vis BAU.

3.1 Freight transport

The INDC specifies a target to increase the share of rail in land transportation from 36 to 45 %. It is not clearly spelt whether this is for freight or passenger transport. However the target compliments the dedicated freight corridors and therefore we consider this as a target for freight. The DFC are expected to ease the load on road freight which runs on diesel powered trucks. The scenario assumes that in addition to the Eastern and Western Corridors currently under construction, additional length will be implemented. This shift can result in cumulative reduction of 132 $MtCO_2$ between 2015 and 2030 and 625 $MtCO_2$ between 2015 and 2050. Higher reductions can be achieved if the electricity is decarbonized. The shift from road towards rail will also deliver energy savings as well as a diversification away from oil (Figure 2).

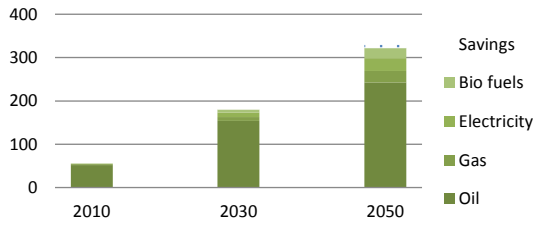

Figure 2: Energy Demand and Savings from Sustainable freight strategy (Mtoe)

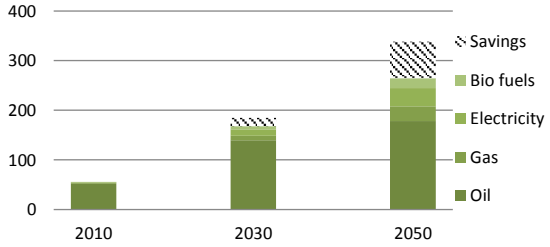

Figure 3: Energy demand and savings from Sustainable mobility strategy (Mtoe)

3.2 Passenger Mobility

The INDC's focuses on moving people rather than vehicles and a key initiative mentioned is Mass Rapid Transit System (MRTS) for Indian cities (Table 1). Urban development initiatives including the Smart city mission to develop 100 smart cities and the urban renewal mission (AMRUT) to providing basic infrastructure in urban centres, including transport were included in the scenario storyline. Initiatives for strengthening public transport and intercity transport are also incorporated in the scenario. Results show that this shift towards public transport in cities and rail for intercity transportation can result in cumulative reduction of around 221 $MtCO_2$ between 2015 and 2030 and 2,105 $MtCO_2$ between 2015 and 2050. This shift to cleaner modes will also deliver substantial savings for energy and lead to a reduction in oil demand (Figure 3).

3.3 Fuel Efficiency

Vehicle ownership are expected to increase in future (Dhar et al., 2015) and though the vehicle fleets are new and quite efficient increasing incomes can shift the preference of consumers to larger vehicles. The INDC has therefore focussed on vehicle efficiency and clean fuels to mitigate the externalities from the growth of vehicles. Globally, most developed countries and several developing countries have introduced stringent fuel economy standards (Zhao et al., 2016). In India, passenger vehicle fuel-efficiency standards are under implementation from April, 2016. This shift towards more efficient vehicles can result in cumulative reduction of around 348 $MtCO_2$ between 2015 and 2030 and 1,620 $MtCO_2$ between 2015 and 2050. This shift will also deliver substantial energy savings (Figure 4). However, since several initiatives take effect in the medium and long term, the reductions are more prominent post 2030.

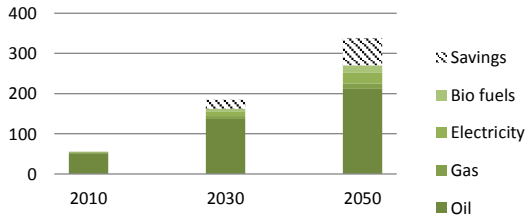

Figure 4: Energy demand and savings from Fuel economy strategy (Mtoe)

3.4 Electric Mobility

The INDC refers to National Electric Mobility Mission Plan 2020 (GoI, 2012) and the Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME India) program (GoI, 2015). The analysis shows that high penetration of electric two wheelers is possible if supported by infrastructure and incentives. However the reductions in CO_2 emissions require decarbonizing electricity (Dhar et al., 2016). This shift towards more EVs can result in cumulative reduction of around 98 $MtCO_2$ between 2015 and 2030 and 1,155 $MtCO_2$ between 2015 and 2050. The reduction potential can increase if electricity is generated from low carbon sources.

3.5 Biofuels

Recent studies have shown the technical and economic feasibility of producing biofuels from agricultural waste and other materials in India (Chakma et al., 2016). India's National Policy on Biofuels targets 20% biofuel

blending targets for diesel and petrol and the government of India has announced incentives to enhance biofuel penetration. India's INDC proposes to increase the proportion of clean and low carbon fuels. The modelling assessments show that cumulative emission savings equal to 797 $MtCO_2e$ can be accrued between 2010 and 2050.

3.6 INDCs and 2 °C Scenario

In the preceding analysis, the paper analysed the mitigation contribution of individual INDC actions. However these actions would happen collectively in practice as well as influenced by the overall global ambitions of achieving a temperature stabilization of 2 ^oC. Under this consolidated case the effects of individual actions are enhanced since the carbon price provide an additional incentive for action. The carbon price was taken as 13.9 USD/tCO_2 in 2020 which increases to 200 USD/tCO_2 in 2045 (Lucas et al., 2013). Figure 5 compares the emission reduction in the INDC scenario and the INDC + 2 ^oC scenario. In the INDC scenario, CO_2 emissions reduce by 329 t in 2050 relative to BAU scenario. In the INDC + 2 ^oC scenario, the CO_2 reductions increase gradually t and by 2030 the reductions are around 46 % from BAU. A more substantial reduction is seen by 2050, when CO_2 emissions reduce by 80 % from BAU. The CO_2 emissions are also decoupled largely from growth in the transport demand.

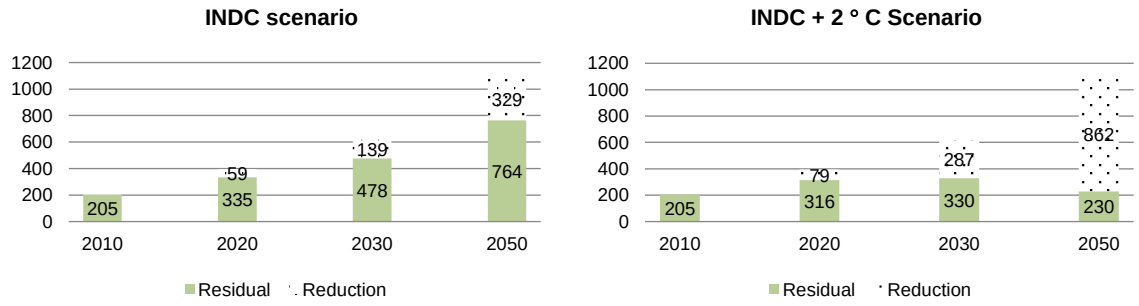

Figure 5: CO_2 reduction ($MtCO_2$)

4. Conclusions

Transport sector is considered relatively less flexible in terms of infrastructures and technology progress. The paper looks at how the transport sector for India will have to be adapted to deliver INDCs as well as deliver the mitigation requirements concomitant with the global 2 ^oC temperature stabilization target. The paper explores individual mitigation contributions from transport INDC strategies relative to BAU scenario. Modelling assessment shows that the highest reduction is achieved through sustainable mobility strategies which include interventions that will reduce transport demand and facilitate shift to low carbon modes. Improving the fuel economy of vehicles is the second most significant wedge. Studies in other countries have shown similar mitigation benefits from improvement of fuel economy standards (Aizura et al., 2010). Results also show that electric vehicles can bring about significant emission savings between 2015 and 2050. However, the reduction achieved till 2030 is not very significant and higher savings accrue post 2030 with the increasing penetration of EVs. Implementation of INDC targets for biofuel blending in petrol and diesel have the potential to reduce 800 x 10^6 tCO_2 emission reductions. Sustainable freight strategies also play a role in India's low carbon transition.
The assessment provides useful insights on the impact of interventions in the short, medium and long term which can be useful in developing a roadmap for implementation. For instance, fuel economy targets and biofuel blending policies can be implemented in the immediate time frame while implementation of large infrastructure projects including high speed rail and freight corridors take longer and therefore the mitigation benefits accrue in the medium and long term. Similarly, electric vehicle policies and infrastructure combined with decarbonisation of electricity can facilitate higher penetration (Dhar et al., 2016), deliver emission reductions as well as environment and development benefits (Majumdar et al., 2014). The increase in efficiency of passenger and freight transportation reduces the overall energy demand from the transport sector. The switch to biofuels and electric vehicles helps diversify the fuel mix thereby reducing dependence on oil and benefitting India's energy security. Collectively, transport INDC strategies for India deliver over 6,000 x 10^6 tCO_2 emission reductions compared to the BAU scenario. However, mitigation requirements consistent with the global 2 ^oC goal may require deeper cuts. In the overall, the assessment highlights the potential of significant and early investments in infrastructures and incentives to promote sustainable transport strategies including cleaner fuels

and technologies to achieve the twin objectives of meeting the global 2 °C mitigation target and ensuring local and national sustainable development benefits.

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